

# Extraterrestrial Life

# Extraterrestrial Life

Extraterrestrial: outside the Earth, leads us to the Universe

Life: Terrestrial knowledge

We only KNOW about life on Earth (will use as “model”)

Danger of “Earth Chauvinism”

## **Objectives:**

Scientific Perspective

Understand connection between Universe and Life

Give you tools to make your **own** judgments

## **Controversial Issues:**

Evolution

Visits by Aliens (UFO' s)

## **Themes:**

Cosmic Evolution

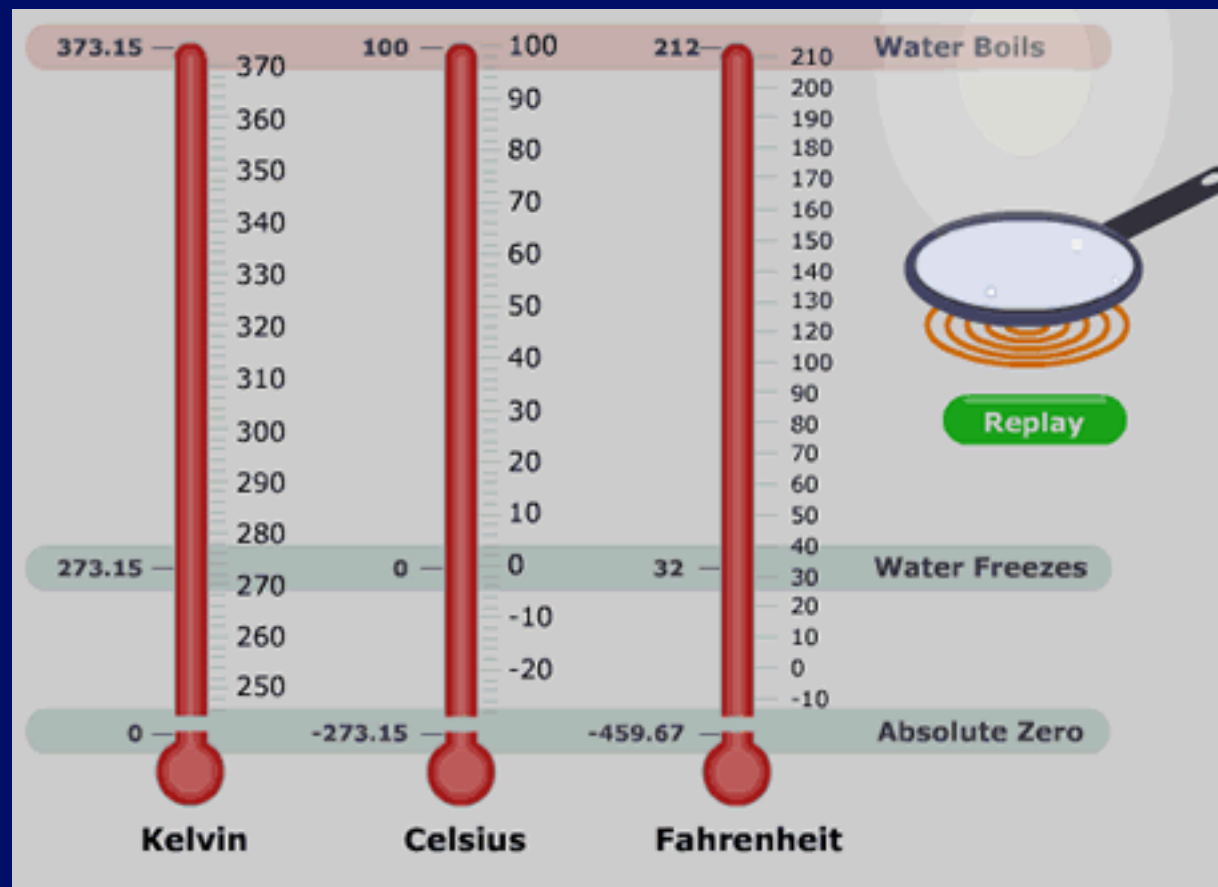
The Drake Equation

Contact

# Mathematics



# Temperature Scales



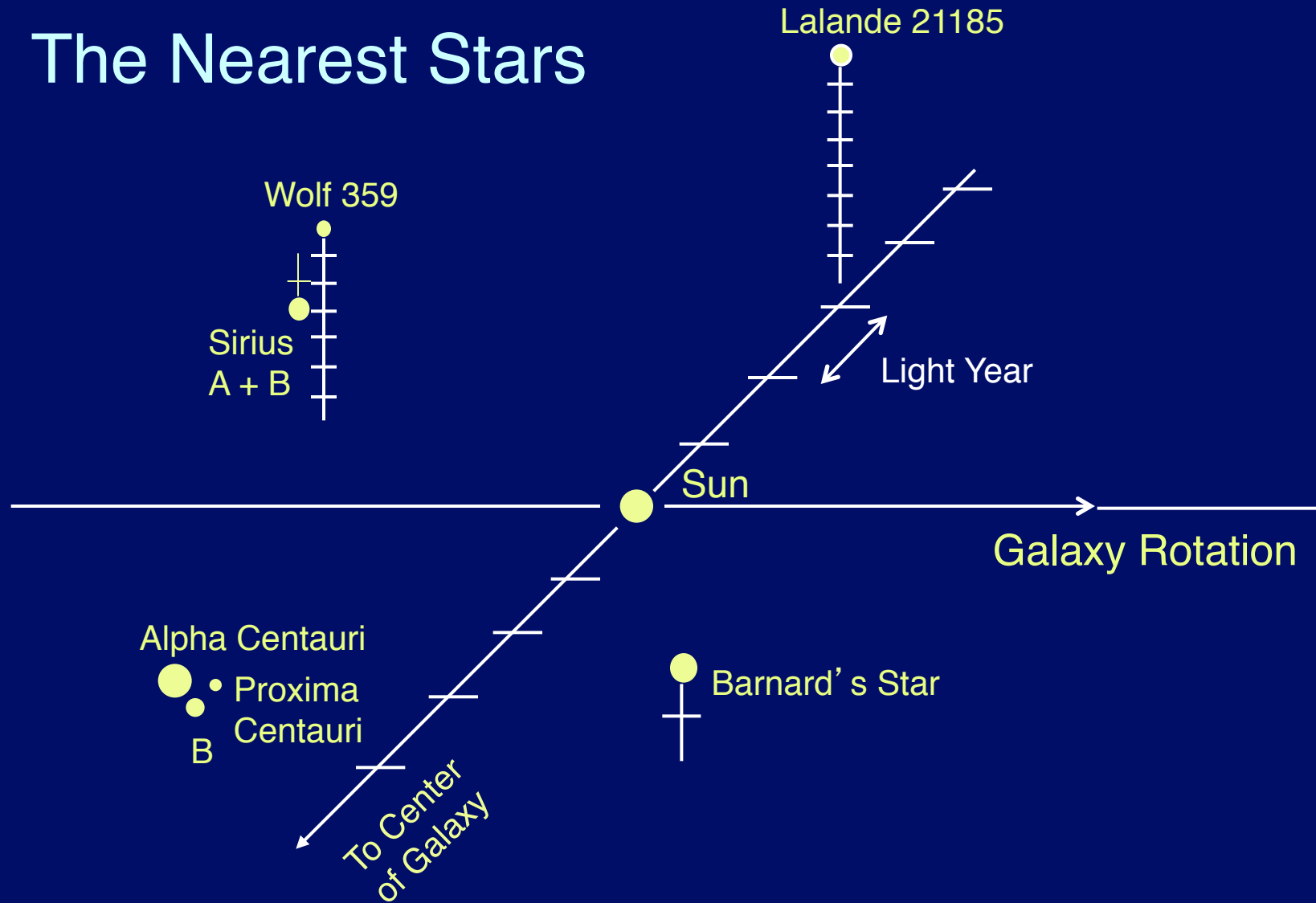
# The Cosmic Context

## ***T H E N E A R E S T S T A R S***

<b>Star</b>	<b>Color</b>	<b>Distance</b>	<b>Closest Approach</b>	<b>Minimum Distance</b>
Sun	Yellow	0.0		
Alpha Centauri A	Yellow	4.3	29,000 A.D.	3.2
Alpha Centauri B	Orange	4.3	29,000 A.D.	3.2
Proxima Centauri	Red	4.2	28,000 A.D.	3.2
Barnard's Star	Red	5.9	12,000 A.D.	3.8
Wolf 359	Red	7.8	13,000 B.C.	7.3
Lalande 21185	Red	8.2	22,000 A.D.	4.6
Sirius A	White	8.6	64,000 A.D.	7.7
Sirius B	White	8.6	64,000 A.D.	7.7

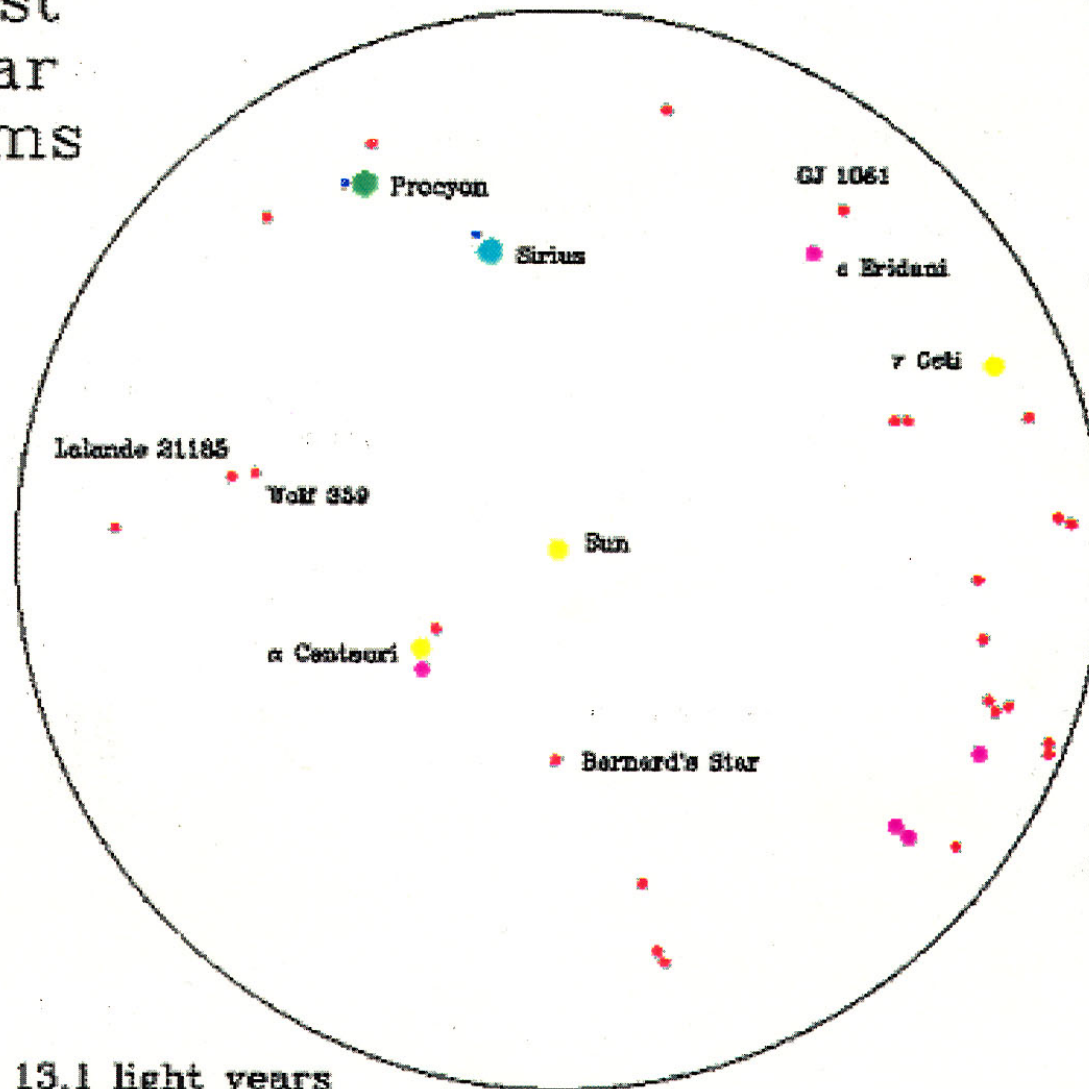
*Note: Distances are in light-years with reference to the sun.*

# The Nearest Stars



# 25 Nearest Star Systems

## Nearest 25 Star Systems



### Five Nearest Systems

1.  $\alpha$  Centauri
2. Barnard's Star
3. Wolf 359
4. Lalande 21185
5. Sirius

### NEOSHS Discovery

01. GJ 1061  
(11.8 light years)

### Five Brightest Systems Among Nearest 25

1. Sirius
2.  $\alpha$  Centauri
3. Procyon
4.  $\gamma$  Ceti
5.  $\epsilon$  Eridani

horizon = 13.1 light years

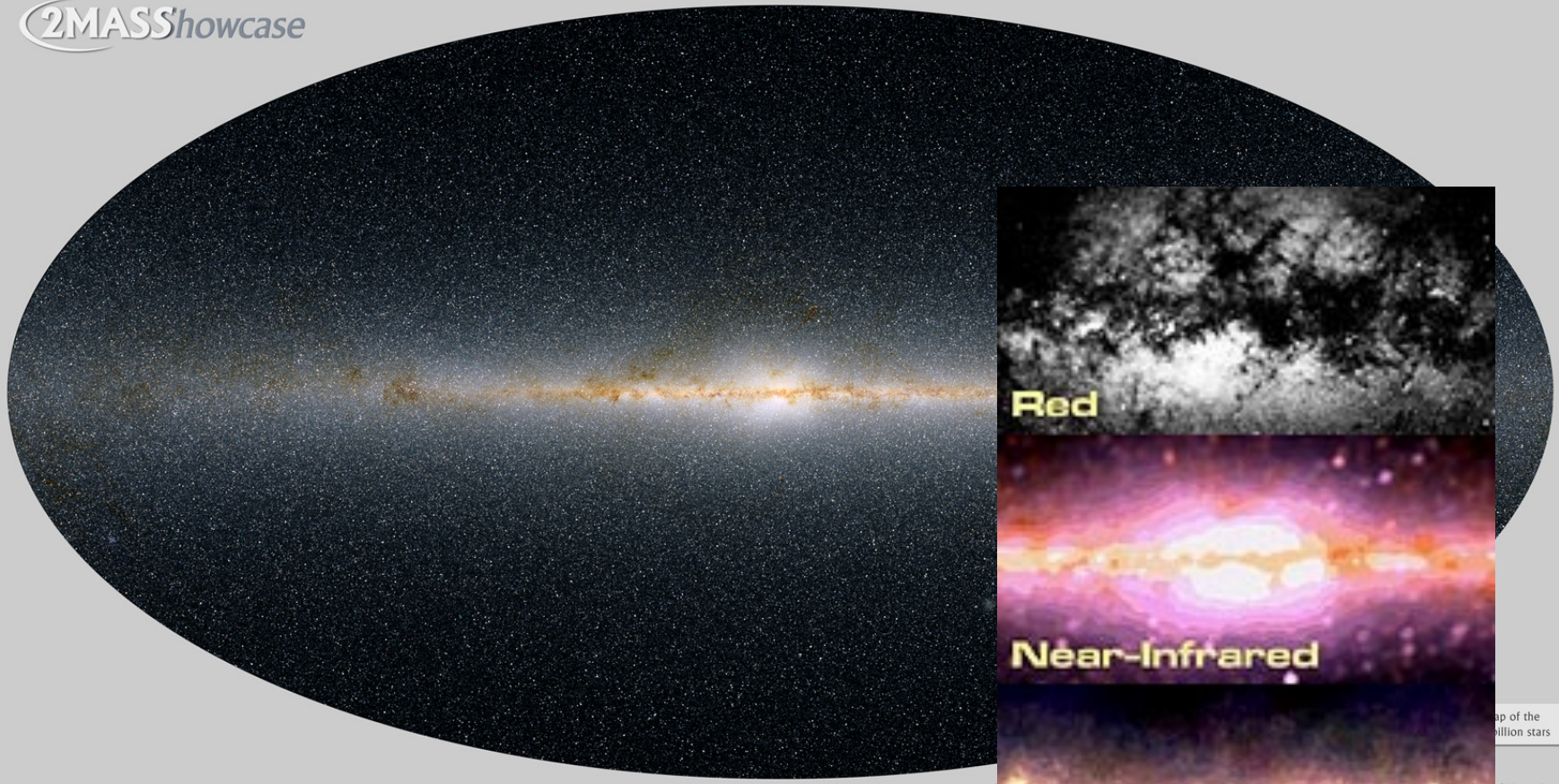
## Larger Structures

- Milky Way Galaxy 100,000 ( $10^5$ ) ly across
- Local Group about 3 million ( $3 \times 10^6$ ) ly
- Virgo Cluster about 30 million ( $3 \times 10^7$ ) ly
- Most distant galaxies we can see are about 13 billion ( $13 \times 10^9$ ) ly away



# The Milky Way

2MASS Showcase



Red

Near-Infrared

Far-Infrared



$10^5$  light-years

Map of the  
million stars

of Massachusetts

# Our Location in the Milky Way





# The Local Group

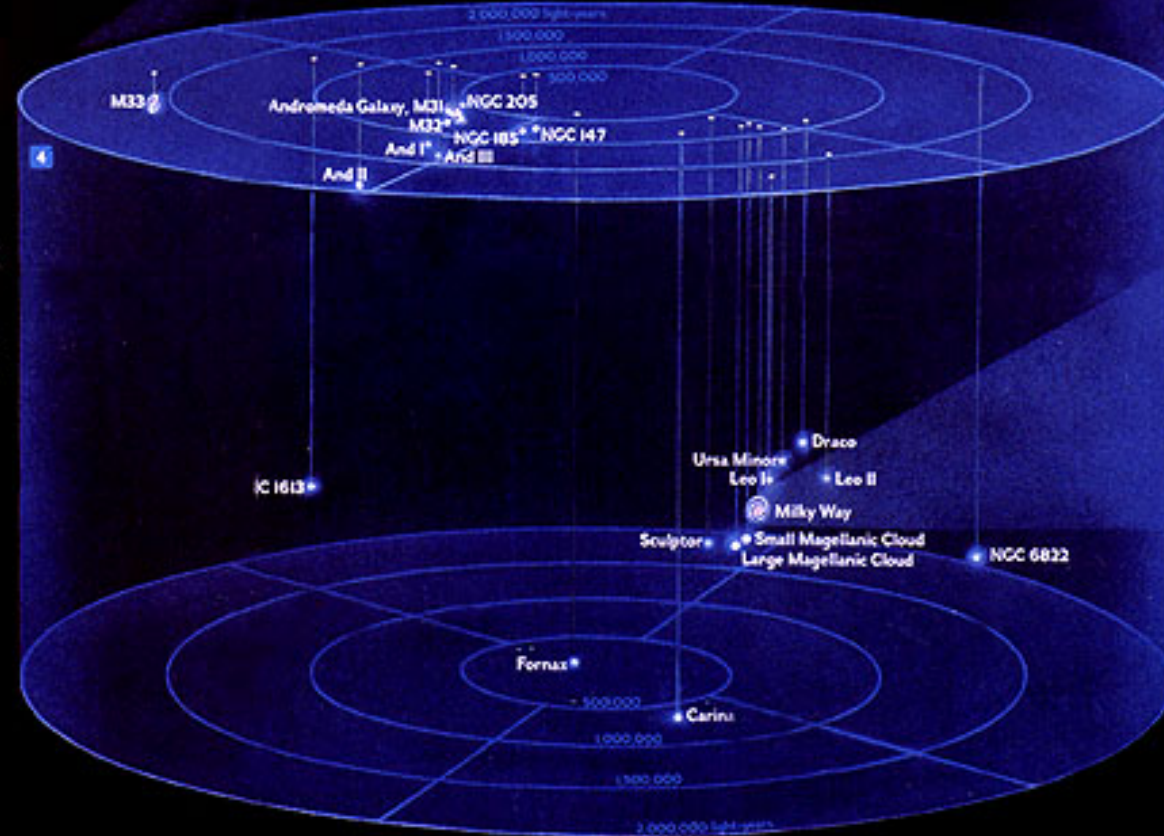
2 million light years

## 4. LOCAL GROUP

Beyond the Milky Way we have located galaxies in every direction. Our own is part of a loosely bound cluster of some 20 galaxies, called prosaically the Local Group. "Galaxies are to astronomy what atoms are to physics," astronomer Allan Sandage has said, and this group illustrates the variations.

The Milky Way, its sister Andromeda (M31), and the smaller M33 are fast-rotating spirals. Hundreds of star clusters and dust clouds lie within the Andromeda galaxy, itself once mistakenly identified as a nebula, or cloud, in the Milky Way galaxy.

NGC 205 is an elliptical galaxy, consisting mainly of old stars. The Large and Small Magellanic Clouds are irregular galaxies, described as haze in the southern sky by Magellan's crew in 1520. These member galaxies, all moving in random paths, are held together by gravity, even as the universe expands.



# Central Part of Virgo Cluster



$3 \times 10^7$  light-years away

# The Hubble Deep Field



Try this Link

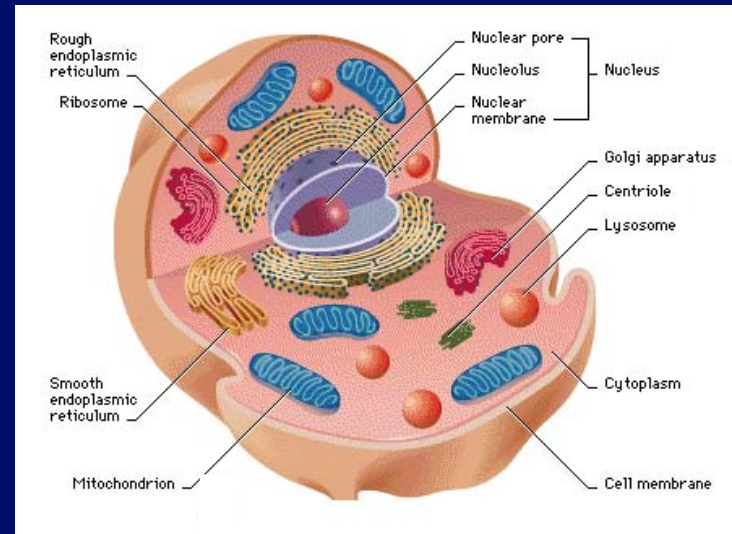
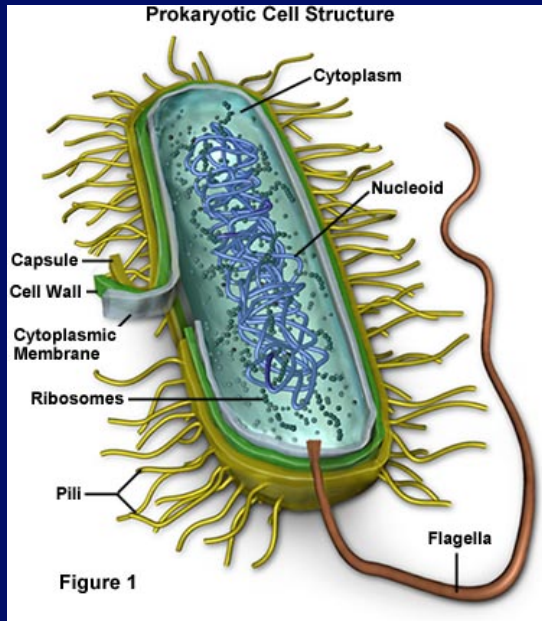
<http://www.atlasoftheuniverse.com/index.html>



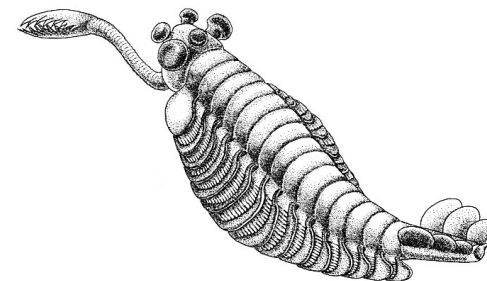
# Questions

- How far from Earth are the astronauts in the Space Station?
- How far have humans traveled (in light-time units)?
- What fraction of the distance to the nearest star is that?
- Are we likely to travel to another star in your lifetimes?

# Life



126 | WONDERFUL LIFE



3.21. *Opabinia*, showing the frontal nozzle with terminal claw, five eyes on the head, body sections with gills on top, and the tail piece in three segments. Drawn by Marianne Collins.



## Five Attributes of Life

1. Composed of **Organic Molecules** (Carbon Based)
2. Engages in **Metabolism**
3. **Reproduces**
4. **Mutates** (Evolves)
5. Changes in Response to Environment (**Sensitivity**)

# Questions

- Can you think of a counter-example to each of these?
- Something alive without these attributes?
- Something not alive **with** these attributes?

# Alternative Approach to Definition of Life

Based on Ecological aspect

Clare Folsom (Onsager-Morowitz)

“Life is that property of Matter that results in the Coupled Cycling of bioelements in Aqueous Solution, ultimately driven by radiant energy to attain Maximum Complexity”

Very general - but what does it mean?

Gaia - Geochemical & Biological Cycles

Life on Earth as “Organism” (James Lovelock)

# Requirements for Life

**To Make a:**

**You Need:**

Virus

< 17 Elements

Bacteria

~ 17

Human (Mammal)

~ 27

Phosphorus (P) and Potassium (K) in shortest supply

Average Human Being contains  $6 \times 10^{27}$  atoms

⇒ At least one atom of every stable element and some unstable (radioactive) elements ( $^{14}\text{C}$ ,  $^3\text{H}$ ,  $^{40}\text{K}$ )

⇒ Some atoms from every species that ever existed

Leaving aside rare elements, all life has similar composition: (All % by number of atoms)

<u>Symbol</u>	<u>Element</u>	<u>Bacteria</u>	<u>Human Beings</u>
H	Hydrogen	63%	61%
O	Oxygen	29%	26%
C	Carbon	6.4%	10.5%
N	Nitrogen	1.4%	2.4%
P	Phosphorus	0.12%	0.13%
Ca	Calcium		0.23%
S	Sulfur	0.06%	0.13%

HCON	Essential, most common
P,S	Also essential
Ca	Bones

Also Fe (Iron) Hemoglobin  
Mg (Magnesium) Chlorophyll

## Composition of the Earth:

Element	Crust	Ocean	Atmosphere
Oxygen	47%	~ 33%	21%
Silicon	28%		
Nitrogen			78%
Hydrogen		~67%	(0.011% Carbon)

Question: Which is most similar to that of life?

## Composition of life **more like** Composition of Sun (Universe)

Symbol	Element	% in Sun
H	Hydrogen	93%
He	Helium	6.4%
O	Oxygen	0.06%
C	Carbon	0.03%
N	Nitrogen	0.011%

Aside from He, **HOCN**

Where did these elements come from?

## Appendix 5

Drake Equation:

$$N = R_* f_p n_e f_\ell f_i f_c L$$

- N = number of communicable civilizations in our galaxy
- $R_*$  = rate at which stars form
- $f_p$  = fraction of stars which have planetary systems
- $n_e$  = number of planets, per planetary system, which are suitable for life
- $f_\ell$  = fraction of planets suitable for life on which life actually arises
- $f_i$  = fraction of life-bearing planets where intelligence develops
- $f_c$  = fraction of planets with intelligent life which develop a technological phase during which there is capability for and interest in interstellar communication
- L = average lifetime of communicable civilizations
- r = average distance to nearest civilization

	$R_*$	$f_p$	$n_e$	$f_\ell$	$f_i$	$f_c$	L	N	r
Estimate									
Birthrate									

if  $N > 8000$   $r = \frac{10^4 \text{ l.y.}}{N^{1/3}}$

if  $N < 8000$   $r = \frac{5 \times 10^4 \text{ l.y.}}{N^{1/2}}$

# The Drake Equation



# Drake Equation:

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